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None

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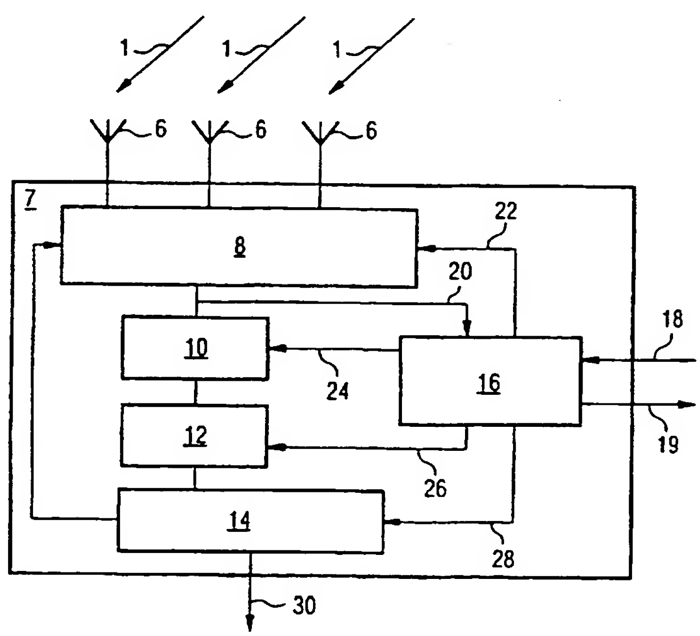
(54) Abstract Title
Network controlled receiver filter for base stations

(57) The configuration of a radio base station receiver 7 filter is controlled by the network controller to which the base station is connected. The configuration may be determined by the network controller based on characteristics of the signal 1 received from a mobile at the base station. The controller may configure the filter 10, 12 as a high, low, bandpass, comb or finite impulse response filter. The arrangement may also incorporate an adaptive antenna system 6, 8.

FIG 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG 1

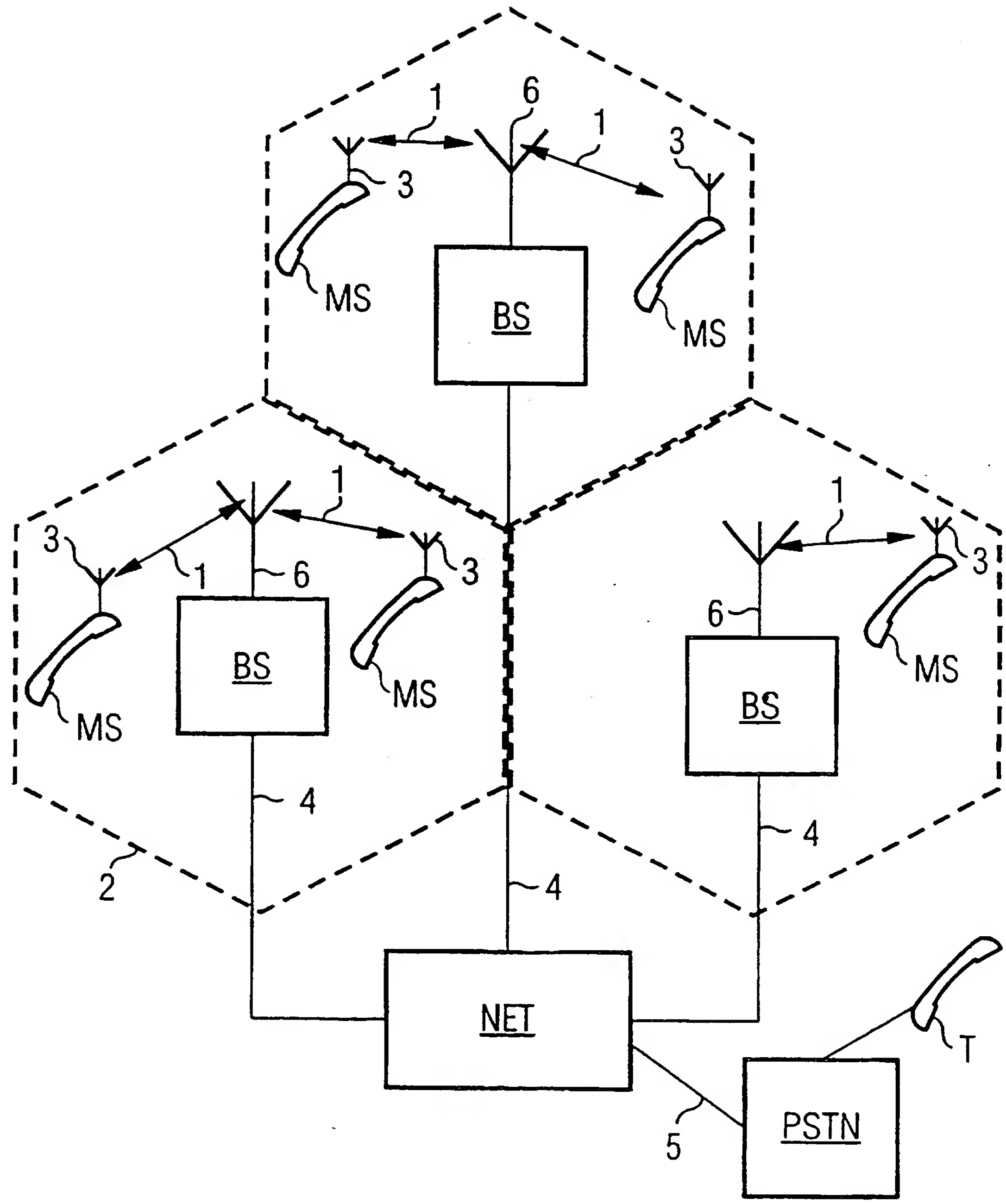


FIG 1

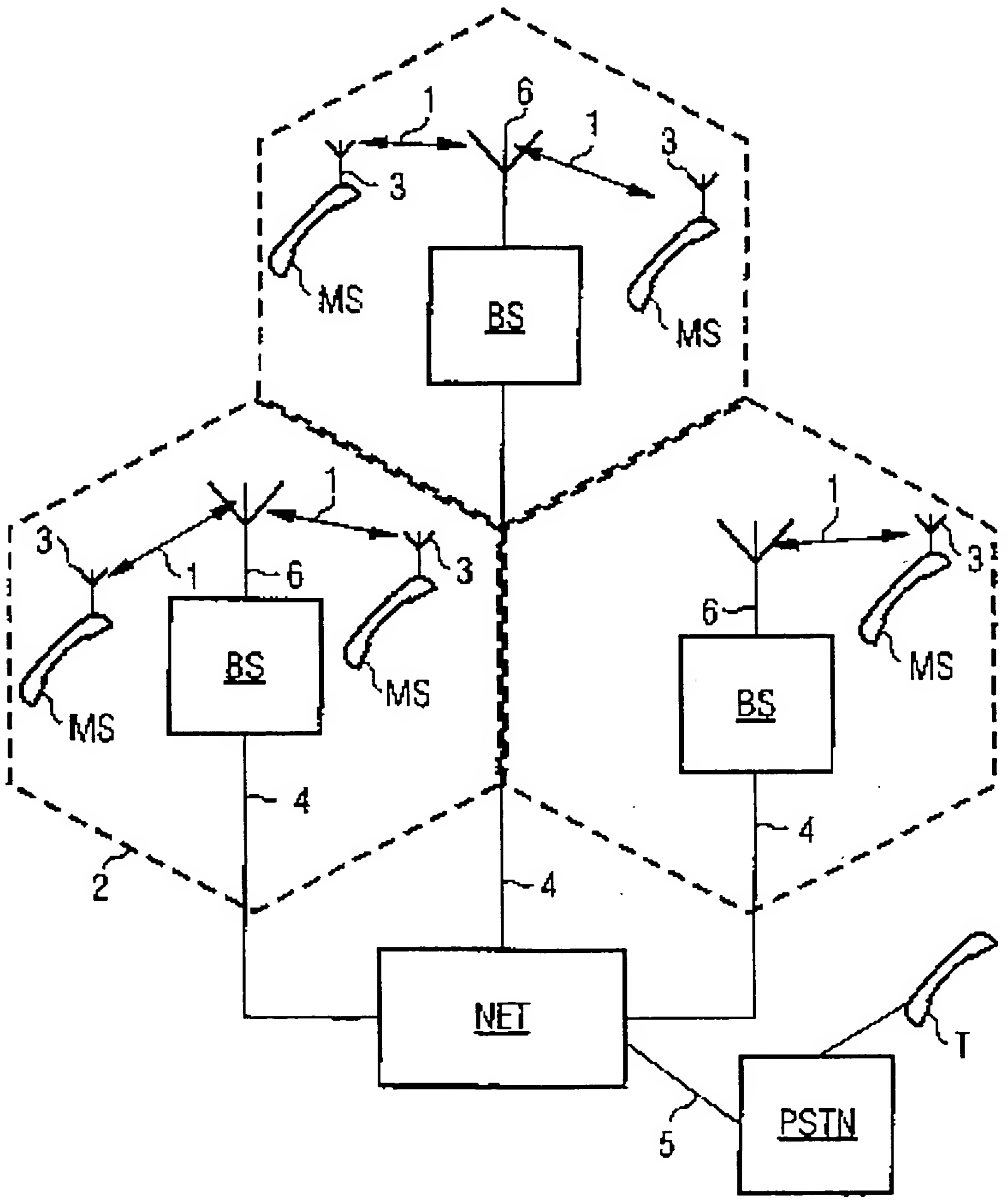


FIG 2

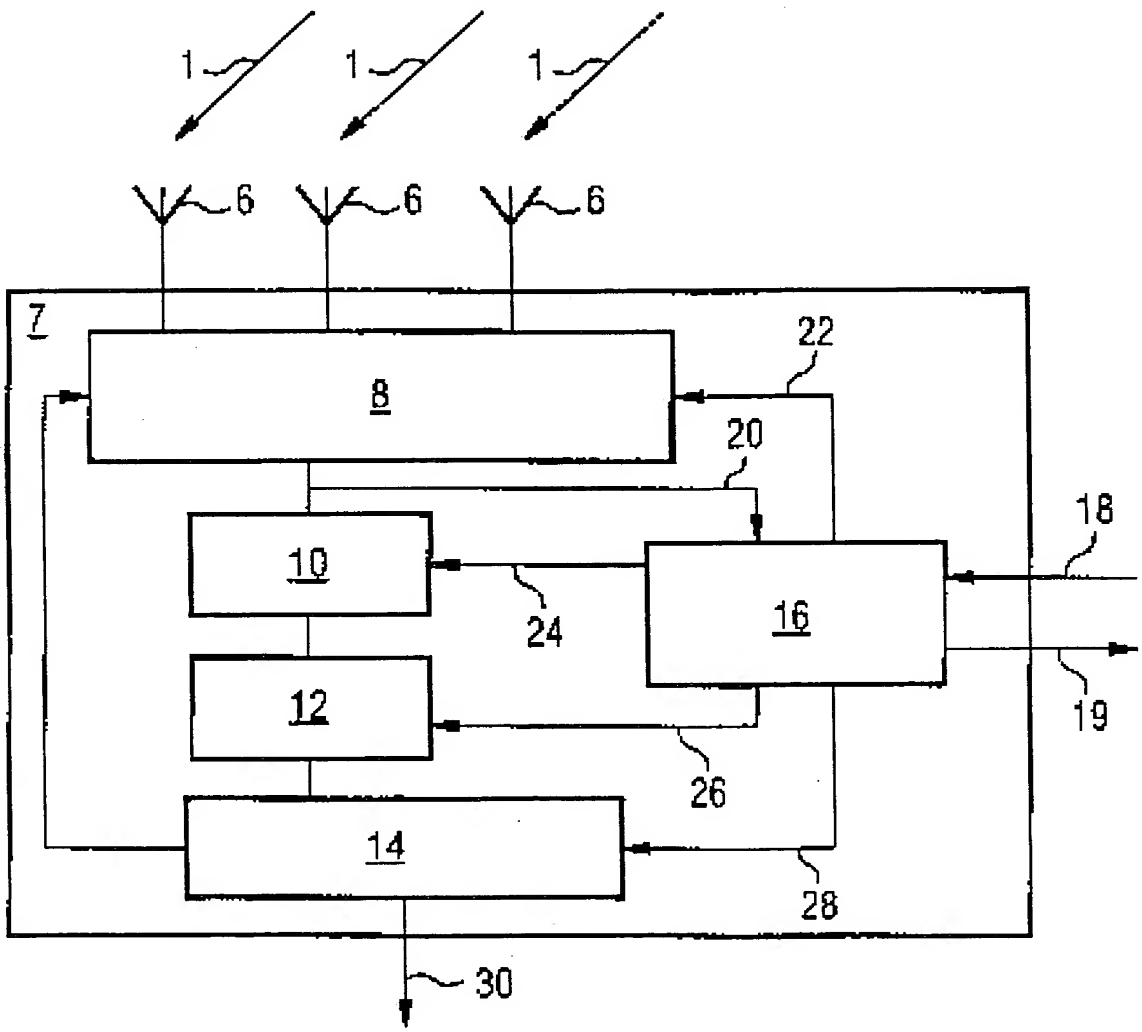
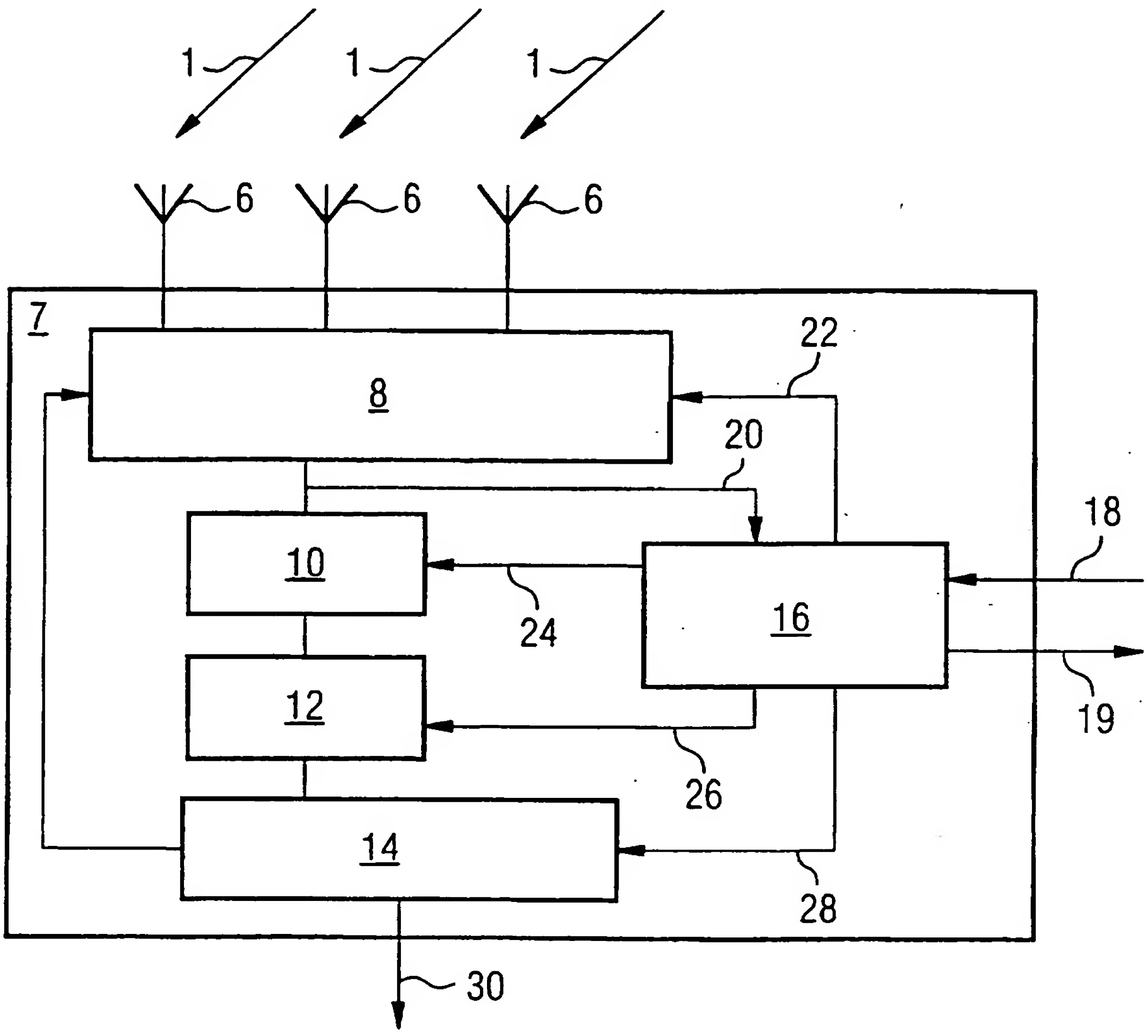


FIG 2



Description of invention

Mobile radio communications network and method of configuring a mobile radio network

The present invention relates to mobile radio communications networks and in particular to apparatus and methods for configuring mobile radio networks.

Mobile radio networks are known to be comprised of a plurality of interconnected base stations which are spatially disposed and arranged to provide a radio coverage area within which mobile stations enjoy a facility of communicating data using radio signals. Associated with each base station of the network is a geographical area within which radio communications can be effected with that base station in preference to any other base station. The geographical area is known as a cell, and together the cells form the radio coverage area of the mobile radio network.

A characteristic of mobile radio networks is that a radio frequency bandwidth within which radio signals are transmitted is used contemporaneously by more than one mobile station for signals transmitted between the mobile stations and the base stations, and correspondingly more than one base station for signals transmitted from the base stations to the mobile stations with an effect that a number of telephone conversations which may be supported contemporaneously by the mobile radio network is increased. As a result, data must be recovered from a wanted signal in the presence of co-channel interfering signals.

In the case of time division mobile radio network such as one which operates in accordance with the Global System for Mobiles (GSM), radio frequency carrier signals are divided in time, into time slots which are assigned to different mobile stations. However, each of the base stations, within a pre-

determined cluster of base stations is assigned a set of radio frequency carriers. These radio frequency carriers are reassigned to other base stations in accordance with a repetition of the cluster so that the radio frequencies are reused in accordance with a predetermined frequency reuse pattern which is reflected in the clusters of base stations. In the case of Code Division Multiple Access (CDMA) systems, radio signals are arranged to be transmitted contemporaneously in the same radio frequency bandwidth at the same time with signals transmitted from other mobile stations. The signals from different mobile stations are separated by combining the radio signals with unique spreading codes which are associated with the mobile stations. By comparing the received radio signals with a spreading code associated with a wanted signal which is known to the receiver, the data represented by the wanted signal can be recovered in spite of the presence of conntemporaneously received interfering signals transmitted from other mobile stations. Mobile radio networks therefore compromise between increasing a number of communications channels that can be supported contemporaneously and tolerating an amount of co-channel interference caused at radio receivers of the network, whilst still permitting data to be communicated.

Although base stations within a mobile radio network are deployed so as to effect a most efficient use of a radio frequency spectrum allocated to the mobile radio network, some base stations in the network will experience a greater level of co-channel interference than other base stations of the network. The co-channel interference experienced by a receiver at each of the base stations will depend on the number of mobile stations within the cell associated with the base station and the propagation conditions experienced by the radio signals transmitted to that base station. Similarly, adjacent channel interference experienced by each of the receivers of the base station will depend, inter alia,

on an amount of frequency drift experienced by each of the radio signals transmitted by the mobile stations within the cell, and the out of band interference generated from radio systems operating in neighbouring frequency bands.

Within each of the base stations of a mobile radio network a receiver filter is provided in order, as far as possible, to reject co-channel interference and adjacent channel interference. Characteristics of the receiver filters are set by filter parameters in known radio networks to some pre-determined value which provides a satisfactory performance in all conditions. However such pre-determined filter parameters do not obtain optimum performance since the levels of co-channel and adjacent interference will be different in each individual case. On the other hand a fully adaptive automatic choice of parameters is often very complicated and could provoke instabilities in a case where the base station continually attempts to adapt the filter parameters whilst the characteristics of the interference are changing, to the effect that, an optimum choice of filter parameters is never reached.

It is an object, therefore, of the present invention to provide a mobile radio network in which the base stations of the network are more closely optimised to the characteristics of received radio signals which are experienced at each location of the base stations.

The present invention resides generally in a mobile radio network comprised of base stations having configurable receiver filters and a mobile radio network controller which operates to configure the receiver filters in accordance with the characteristics of radio signals received at each of the base stations. These characteristics may include an amount of co-channel and adjacent channel interference power experienced when detecting a wanted radio signal.

According to the present invention there is provided a mobile radio communications network comprising a plurality of operatively coupled base stations arranged in use to communicate data with mobile stations using radio signals, and each having a receiver which operates in use to detect and recover data from the radio signals, and a mobile network controller, coupled to the base stations and arranged to monitor and control the operation of the base stations by communicating control data with the base stations, characterised in that each of the receivers has a controllable receiver filter the configuration of which is effected under influence of the mobile network controller, whereby the receiver filter of each base station is configured individually.

The co-channel interference and the adjacent channel interference experienced by a receiver at each of the base stations will be different for each base station. As such no one receiver filter characteristic can be used in every base station in order to provide optimum performance. However, by providing the base stations with configurable filters and arranging for the mobile radio network controller to configure the receiver filters in dependence upon the characteristics of the radio signals received at the base stations, the performance of the receiver filter can be substantially optimised for each base station individually.

Advantageously, the receivers may further have means to configure the controllable receiver filters in accordance with filter control data. Furthermore, the receivers may be further provided with means for measuring the characteristics of the received signals, and the mobile network controller may operate to configure the controllable filters consequent upon the measured characteristics.

The means to configure the controllable filters may have a set of filter parameters each of which provides the filter

with a pre-determined impulse response having particular filter characteristics, and the filter control data may be indicative of which of the filter parameters is to be used to configure the filter. The filter control data may include the filter parameters which are sent to the base station by the mobile radio network controller. The filter parameters may, for example, configure the filter as a high-pass, a low-pass or a band-pass filter. The configurable filter may be configured as a comb filter and the filter parameters may include providing zeros of the channel impulse response of the comb filter.

It is a further advantage for the controllable filter to include a finite impulse response filter, and the or each filter parameter includes the coefficients of the finite impulse response filter. The filter parameters may furthermore include the number of stages of the finite impulse response filter and the coefficient associated with each stage.

The means to configure the controllable filter may further include means to adapt the filter coefficients, and the filter parameters may further include a filter coefficients adaptation step size. The receiver may further include an adaptive antenna system having means for adapting antenna coefficients of the adaptive antenna, and the filter parameters may further include antenna adaptation parameters to be used in the means for controlling the adaptive antenna system. The antenna adaptation parameters may include spatial filter coefficients, temporal filter coefficients, a number of taps of the spatial or temporal filter and adaptation step sizes.

According to a further aspect of the present invention, there is provided a method of configuring the parameters of a receiver of each base station of a mobile radio network, the method comprising the steps of measuring characteristics of

radio signals received by the base station, determining consequent upon the measured characteristics appropriate filter parameters for a receiver filter of the base station and arranging under control of a mobile network controller for the receiver filter to be configured in accordance with these parameters.

One object of the present invention will now be described, by way of example only, with reference to the accompanying drawings wherein;

FIGURE 1 is a schematic block diagram of a mobile radio network; and

FIGURE 2 is a schematic block diagram of a base station which is used within the mobile radio network shown in Figure 1.

The present invention finds application in any mobile radio network, but in particular, in mobile radio networks in which mobile stations are arranged to communicate data by transmitting radio signals contemporaneously with other mobiles stations, thereby causing co-channel interference to be generated at the base stations. As such the present invention finds application in both time division multiple access systems such as GSM, in which radio frequency channels are re-used in spatially separated clusters of base stations, or in Code Division Multiple Access (CDMA) systems, such as Wide band-CDMA (W-CDMA) or Time Division-CDMA (TD-CDMA) in which contemporaneously transmitted signals are separated using spreading codes.

As an illustration of an example embodiment of the present invention, a TD-CDMA mobile radio network will be considered, an example of which is shown in Figure 1. In Figure 1 mobile stations MS, operate to communicate data with each other and

with terminals T, attached to a fixed wire network, which may be, for example, a Public Switched Telephone Network PSTN, by communicating data via radio signals represented as lines 1. The cells associated with the base stations BS, are illustrated by the broken line 2. Each of the base stations BS, is provided with a transmit and receiver antenna 6, which facilitates the transmission and reception of radio signals. Similarly, the mobile stations MS are provided with a transmit and receive antenna 8. The radio signals are communicated with the base stations BS, which are connected via conductors 4 to a mobile network controller NET. The mobile network controller NET, operates to provide an interconnection of the base stations of the mobile radio network and to control the configuration of the base stations to the effect of substantially optimising the capacity of the mobile radio network. The mobile network controller NET, also forms a connection with the fixed network, PSTN, through a conductor 5.

The mobile radio network illustrated in Figure 1 is arranged to provide the mobile stations MS, with access to radio communications channels in accordance with TD-CDMA. TD-CDMA supports a plurality of communications channels in the same cell on the same frequency and in the same time slots. To detect and recover data from wanted radio signals, the base stations BS and mobile stations MS are provided with means for detecting contemporaneously received unwanted signals and for cancelling these unwanted signals from a wanted signal, from which the receiver is arranged to recover data. Although the receivers within the mobile station and the base station are provided with means for cancelling unwanted signals from other mobile stations transmitted contemporaneously within the cell, there is a limit to an amount of unwanted signal power or co-channel interference which a receiver within the base station can tolerate. Most of the co-channel interference is produced within the cell. In order to optimise the capacity of the mobile radio network, the

frequency channels allocated to each of the base stations are re-used and also allocated to other base stations, which are, as much as possible, spatially separated. By spatially separating the base stations which are using the same frequencies, a level of unwanted interfering signal power which is detected at a receiver from within a base station or mobile station of a cell, originating from another cell using the same frequency, is minimised as a result of a propagation path loss between the cells. In this way the capacity of a mobile radio network operating in accordance with TD-CDMA is substantially optimised.

As already explained one of the limitations on the performance and capacity of the mobile radio network shown in Figure 1, is an amount of co-channel interference which may be tolerated by the receiver. To minimise the co-channel interference, the base stations within the mobile radio network are provided with receiver filters which are arranged, as far as possible, to reject unwanted co-channel interference. A further disturbance to the wanted radio signal is produced from adjacent channel interference in which signals from neighbouring frequency channels spill over into the frequency channel of the wanted signal, and serve to increase the noise power with respect to the wanted signal. The adjacent channel interference may be caused by, for example, another radio system operating in an adjacent bandwidth to the mobile radio system, or may result from frequency shifts to radio signals transmitted by the base stations or mobile stations within the mobile radio network to the effect that radio signals from an adjacent communications channel introduce signal power into the radio frequency bandwidth of the wanted signal.

The characteristics of the receiver filter in each of the base stations is determined in accordance with a set of filter parameters which define an amount of an attenuation with respect to frequency which the received signals

experience when passing through the receiver filter. However the choice of filter parameters will depend on the type and characteristics of the interference received at the base station. For example, for a strong adjacent channel interferer, the receiver filter should be a very narrow low pass filter. However, this has rather poor sensitivity to co-channel interference. For a strong co-channel interferer the filter should show a high pass behaviour within the frequency channel of the wanted signal. This should thereafter be followed by moderate low pass filter to suppress adjacent channel interference. This is also appropriate for a GSM system, for example, where radio frequency channels are separated by something in the order of 400 kHz or more. However any compromise between the optimum case for adjacent channel and co-channel interference produces a sub-optimum receiver performance. As a result a standard set of pre-determined filter parameters for the receiver filter will always introduce a limitation on the performance of the mobile radio network, because the base stations will suffer a greater amount of co-channel or adjacent channel interference than they would do if the filter parameters for the receiver filter were set to an optimum value.

In order to provide the base stations within the mobile radio network shown in Figure 1 with an arrangement in which the parameters of the receiver filter are selected in dependence upon the interference conditions experienced, each of the base stations BS, within the mobile radio network, is provided with a configurable receiver filter which may be configured using control data under influence from the mobile network controller. A receiver embodied within one of the base stations BS, with this facility, is shown in Figure 2 where parts also appearing in Figure 1 bear identical numerical designations.

In Figure 2, a receiver 7, is shown which forms part of one of the base stations shown in Figure 1. The receiver is provided with a plurality of antennas 6, which are connected to a adaptive antenna combiner 8, which together with the antennas 6, forms an adaptive antenna system. The radio signals 1 which are detected by the antennas 6 are combined by the adaptive antenna combiner 8, to form a composite signal which is fed to a first receiver filter 10. After being filtered by the first receiver filter 10, the signal is then filtered by a second receiver filter 12 coupled to an output of the first receiver filter 10, and the signal after filtering by the second receiver filter 12, is fed to a data detector 14. The data detector 14, operates to recover the data communicated by the radio signals 1, and also to generate control signals for controlling the parameters of the adaptive antenna combiner 8. The recovered data is output on a conductor 30.

The first and second receiver filters 10, 12, are configurable receiver filters and are configured in accordance with filter parameters which are fed, for example, from a filter controller 16. The filter controller 16 is provided with an input 18 which forms part of the conductors 4, which connect the base stations BS, of the mobile radio network to the mobile radio network controller, NET. The filter controller 16, also has an input 20, from the output of the adaptive antenna combiner 8, and an output 22, to the adaptive antenna combiner and an output 24 to the first receiver filter, and the second receiver filter 26.

In operation the filter controller 16 receives the composite radio signals 1 from the input conductor 20. The filter controller 16, then operates to analyse a relative amount of disturbing signals such as adjacent channel and co-channel interference experienced by the base station as detected at the antennas 6. The analysis of the interference detected at the receiver antennas is then passed to the mobile network

controller NET, via an output conductor 19, which forms part of the conductors 4, via which the base station is connected to the network controller. In dependence upon the result of the analysis of the interference, the mobile network controller NET, operates to signal to the filter controller 16 via an input conductor 18, which of a set of filter parameters should be used to configure the first and second receiver filters 10, 12. For example the filter controller 16, may be provided with a set of filter parameters which broadly define either a high-pass, a low-pass or a band-pass filter. The first and second receiver filters 10, 12 are then loaded with these filter parameters via the conductors 24, 26, in order to optimise the filtering of the received composite radio signals by the first and second receiver filters. Alternatively, the filter parameters themselves could be transmitted to the base station from the network controller in response to the measured characteristics of the received radio signals. In this case the filter controller 16 would receive the filter parameters via the conductor 18 and configure the first and second receiver filters 10, 12 accordingly. The filter parameters may include a decimation rate which is to be used in filtering and hence a number of stages in a tapped delay line of a finite impulse response filter which forms the first or second receiver filters. Furthermore the first or second receiver filters 10, 12, or both could be comb filters in which case the parameters will specify the zeros of the impulse response represented as the coefficients of the tapped delay line. As a further alternative, the filter controller 16, could include a set of filter parameters anyone of which could be loaded into the first or the second receiver filters under control of the network controller NET. Other arrangements for loading the filter parameters, and other filter types, are also envisaged.

In a case where the impulse response of the first and second receiver filters 10, 12, are made to be adaptive in that the

coefficients of the impulse response of these filters is adapted with respect to time, the filter controller may further operate to change a rate of adaptation or adaptation step size of these filters under the influence of the network controller. In this case either the adaptation step size is transmitted to the filter controller 16, from the network controller NET, or a set of adaptation step sizes is stored in the filter controller 16, and selection of these adaptation step sizes is arranged in accordance with signals transmitted from the network controller NET. Other ways of adjusting the adaptation step size are also envisaged.

The adaptive antenna combiner 8, shown in Figure 2 may be arranged as described in the co-pending United Kingdom patent application No. 9804785.5. In this case, one parameter used in the adaptive antenna combiner is an adaptation step size used in a spatial and temporal filter forming part of the adaptive antenna system. As with the impulse response of the receiver filters 10, 12, the adaptation rate or adaptation step size may be optimised in dependence upon a relative rate at which mobile stations are moving. This is required because the adaptation step size is a compromise between noise introduced by inaccuracies in the adaptation process and noise introduced by an inability to track changes in the impulse response fast enough. For example, if it is found that mobile stations within the cells served by the base station are moving at a relatively high rate, such as if the cell serves a motorway or railway line, and therefore require the impulse response coefficients to change rapidly, then a relatively large adaptation step size is required. If, on the other hand, for example, the base station is serving mobile stations in a pedestrian area, then a smaller adaptation step size is required. As such the adaptation step size may be optimised individually for each base station in accordance with the measured characteristics of the radio signals provided to the filter controller 16. Furthermore, the filter controller 16, may operate to introduce further parameters

into the adaptive antenna combiner 8, such as a number of taps to be used in a spatial filter coupled to the antennas 6, and the number of taps which appear in a temporal filter associated with each of the antennas.

Various modifications may be made to the example embodiment as herein before described, without departing from the scope of the present invention. For example other filter types than those mentioned above are envisaged, and other means for configuring these filter types are also possible whilst still falling within the scope of the present invention.

CLAIMS:

1. A mobile radio communications network comprising
- a plurality of operatively coupled base stations (BS) arranged in use to communicate data with mobile stations (MS) using radio signals (1),
- each having a receiver (7) which operates in use to detect and recover data from said radio signals (1), and
- a mobile network controller (NET) coupled to the base stations (BS) and arranged to monitor and control the operation of the base stations (BS) by communicating control data with said base stations, characterised in that
- each of said receivers (7) has a controllable receiver filter (10, 12) the configuration of which is effected under influence of the mobile network controller (NET), whereby the receiver filter of each base station is optimised individually.

2. A mobile radio communications network as claimed in Claim 1, wherein said receivers (7) further comprise means (16) to configure the controllable receiver filters (10, 12) in accordance with filter control data.

3. A mobile radio communications network as claimed in any of Claims 1 or 2, wherein said receivers (7) are further provided with means (16) for measuring characteristics of received signals, and said mobile network controller (NET) operates to configure the controllable filters (10, 12) consequent upon said measured characteristics.

4. A mobile radio network as claimed in Claims 2 or 3, wherein the means (16) to configure the controllable filters (10, 12) has a set of filter parameters each of which provides the filters with a pre-determined impulse response having particular filter characteristics, and wherein the filter control data is indicative of which of the filter parameters is to be used to configure the filter.

5. A mobile radio network as claimed in Claim 2 or 3, wherein the filter control data includes the filter parameters which are sent to the base stations by the mobile radio network controller.

6. A mobile radio network as claimed in Claims 4 or 5, wherein the filter parameters configure the filter as a high-pass, a low-pass filter or a band-pass filter or the like.

7. A mobile radio network as claimed in any preceding Claim, wherein the filter parameters configure the filter as a comb filter and the filter parameters include providing zeros of the channel impulse response of the comb filter.

8. A mobile radio network as claimed in any preceding Claim, wherein the controllable filters (10, 12) further include a finite impulse response filter, and the filter parameters include the coefficients of the finite impulse response filter.

9. A mobile radio network as claimed in any preceding Claim, wherein the filter parameters include the number of stages of the finite impulse response filter and the coefficient associated with each stage.

10. A mobile radio network as claimed in Claim 9, wherein the means (16) to configure the controllable filters (10, 12) further includes means to adapt the filter coefficients, and the filter parameters further include a filter coefficients adaptation step size.

11. A mobile radio network as claimed in any preceding claim, wherein the receiver (7) further includes an adaptive antenna system (6, 8) including means (8) for adapting antenna coefficients of the adaptive antenna, and the filter

parameters further include antenna adaptation parameters to be used in the means for controlling the adaptive antenna.

12. A mobile radio network as claimed in any preceding claim, wherein the antenna adaptation parameters include spatial filter coefficients, temporal filter coefficients, a number of taps of the spatial or temporal filter and adaptation step sizes.

13. A method of configuring the parameters of a receiver (7) of each base station (BS) of a mobile radio network, said method comprising the steps of;
- measuring characteristics of radio signals (1) received by the base station (BS);
- determining consequent upon said measured characteristics appropriate filter parameters for a receiver filter (10, 12) of said base station; and
- arranging under control of a mobile network controller for the receiver filter (10, 12) to be configured in accordance with these parameters.

14. A method as claimed in Claim 13, wherein the characteristics of the radio signals (1) include at least one of an amount of adjacent channel and co-channel interference from unwanted radio signals, and wherein the filter parameters are arranged to effect at least one of a low-pass and a high-pass filter to provide rejection of either the adjacent or the co-channel interference signals.

15. A method as claimed in Claim 14, wherein the filter parameters include a set of filter tap coefficients which determine an impulse response of the filter.

16. A method as claimed in any of Claims 13 to 15, wherein the characteristics of the radio signals include a rate at which wanted radio signals change, and the filter parameters

include an amount by which coefficients of the filter are to be adapted.

17. A method as claimed in any of claims 13 to 16, wherein the characteristics of the radio signals include a rate at which wanted radio signals change, and the filter parameters include an amount by which coefficients of the filter are to be adapted.

18. A method as claimed in any of Claims 13 to 17, wherein the receivers (7) further include an adaptive antenna system (6, 8), and the rate of adapting antenna coefficients of the antenna system is set by the mobile network controller consequent upon the characteristics of the radio signals.

19. A mobile radio network as herein before described with reference to the accompanying drawings.

INVESTOR IN PEOPLE

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Application No: GB 9905446.2
Claims searched: 1 to 19

Examiner: Glyn Hughes
Date of search: 12 July 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4L (LECX, LFNB)

Int Cl (Ed.6): H04B 1/10, 1/12, H04Q 7/30

Other: Online: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	None	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		